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Original Article

Local knowledge, identification and selection of shea tree (*Vitellaria paradoxa*) ethnovarieties for pre-breeding in Uganda

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ABSTRACTS

Local knowledge is important in characterizing and selecting shea tree ethnovarieties since the local communities have lived with the species for quite so long. The communities have developed their classification methods based on specific phenotypic traits used to distinguish one ethnovariety from another. This has helped them select and conserve specific genotypes of their interest on farm. Variants of shea trees exist in different populations known by the local communities. This study aimed at identifying and selecting high oil yielding shea tree "ethnovarieties" in Katakwi; Otuke; Amuru; Moyo; Arua and Nakasongola districts of Uganda using local knowledge. The districts were selected because of their long historical association with shea trees which has become part of their socio-cultural and economic lifestyle, so they have broad local knowledge about shea tree variations within their areas. The study aimed at identifying and selecting superior individual shea tree ethnovarieties with high oil yield using local knowledge for seed collection to raise a half sib population. Data was collected in the months of November and December 2017 from 246 shea tree farmers through interviews, 8 focus group discussions conducted, and 6 Key informer interviews with opinion leaders, civic leaders and local leaders in the districts. List of fifteen shea butter tree ethnovarieties with their descriptive characteristics was generated per district. 53.4% of the people who were interviewed were women and 46.4% were men. Data analysis using Statistical Package for Social Sciences (SPSS 20v) was run using multivariate analysis and multiple regression analysis to test for any differences in local knowledge of shea tree

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ethnovarietis. Differences in local knowledge in the research districts was moderately significant with P = 0.043, df = 4 and X^2 =9.837.
Keywords: Oil yield, Traits, Variation, Community, Preferred, indigenous, ethnovarieties

INTRODUCTION

World over, local communities depend on natural resources to meet their basic needs (Agbogidi 2010), and the use patterns of such resources vary with ecological and socio-cultural characteristics of the area (Jamala *et al.*, 2013). Shea tree (*Vitellaria paradoxa*) in particular is a socially, culturally and economically important indigenous fruit tree species of Sudano-Sahelan Africa (Boffa *et al*., 2000). The tree supplies different products and services (fruits, oils, income, cosmetic and medicinal ointments, hair cream, soaps illuminant and water proofing materials, fuels) and ecological roles supporting rural livelihood within its range in Africa (Jasaw *et al.*, 2015 & Lovett 2004). Through their long-term use and interaction with shea trees, local communities develop knowledge of identifying parameters and peculiar characteristics of plants important for their socio-economic wellbeing. These particular practices, norms and knowledge of identifying parameters and peculiar characteristics of plants differentiating one type from the other when packaged together, form local knowledge. This local knowledge is generated and transmitted over time from generation to generation; one social group to another and one agro-ecological zone to the other through experience realized while interacting with the local environment (Carvalho *et al.*, 2011).

In this way, shea tree types with the best traits have been selected over time, forming the basis for naming such plants based on the utilized parts and or the use for which they are applied. Generic names are then applied to the plants based on the different preferred use values by the community. In some cases, phenotypic and morphological characteristics determine the naming although this may change with environment, location and the stage in development of the plant. Farmers' local knowledge can play a major role towards attaining adequate information on plant varieties in a local area since they are always developed over a wide period of time as the communities use and associate with the plant species.

Tree improvement programs need to be put in place to increase the potential benefit of such community preferred traits that builds from local knowledge. In this case, knowledge of phenotypic and genotypic diversity of the species is important for its improvement. The conventional methods of studying phenotypic and genotypic diversity are not very easy to apply to trees because of their large size, long time they take to mature, and the different forms one species may take due to the changes in environment.

Local knowledge is therefore important for understanding the existing diversity in shea trees and for selection of putative traits for improvement. It has been used by researchers elsewhere to characterize and select shea tree ethnovarieties in Africa (Mawa *et al.*, 2017; Gwali 2013 and Nyarko *et al.*, 2012). In this way, the farmers generate a wealth of knowledge and perception of plant traits common to their areas which can aid in selection for improvement (Gwali *et al.*, 2011, Atukunda *et al.*, 2018). Through Farmer Managed Natural Regeneration (FMNR), farmers have been able to select specific genotypes of their interest and conserved them randomly spaced in their farms (Djekota *et al.*, 2014). Such selected genotypes could have been due to random mating and further environmental and genetic variations through other mutants that have generated wide varieties of shea trees on different populations (Sanou *et al.*, 2004).

The objective of the study was to establish the importance of local knowledge in the identification and selection of the preferred shea tree ethnovarieties by the local communities in the six study areas. The study also aimed determining the differences in preference to the different ethnovarieties among the different ethnic groups.

Sampling methods

Data was collected using household surveys, focus group discussions and Key informant interviews with opinion, civic, cultural and local leaders in Katakwi; Otuke; Amuru; Moyo; Arua and Nakasongola districts in Uganda in the months of November and December 2017. These districts were selected because of their long historical association with shea trees which has become part of socio-cultural and economic lifestyle, so they have broad local knowledge about shea tree variations within their areas.

Sample size

A total of 246 shea tree farmers were randomly selected from the six selected districts.
The sample size of 246 respondents was derived as indicated below:

$n= (pqz^2)/e^2$

Where:

p = Present population estimated at 80% or proportion of which attributes is of interest to the researcher.

n = Sample size

q = 100-p

e = Error term (5%)

z = Confidence level e.g. z = 1.96 or 95%

Substituting for the equation, thus:

$n= (0.8*0.2*〖1.96〗^2)/〖0.05〗^2 =245.8 \approx 246$ households surveyed.

The study made use of the lists of all shea tree farmers generated from the study areas by earlier researchers. The farmers in the list in each location were numbered from one till the last and 41 random numbers to represent the farmers were generated using computer Genstat software.

The farmers helped in identifying and selecting shea trees from the different ethnovarieties known for high oil yield. List of the shea trees ethnovarieties was compiled from the focus group discussions, Key informer interviews and individual interviews.

Data analysis

Preference on fifteen shea tree traits was tested on farmer communities with similar backgrounds from six districts of Uganda. Each responding farmer was randomly selected for interviews. Because of the differences in the number of shea tree farmers in each district, the sample size was not uniform. Test for the difference in shea trait preference was run using the Kruskal-Wallis test to determine if there were any statistically significant differences in preference between two or more farming community groups. Decision was taken based on the test result got being guided by the set level of significance (0.05).

RESULTS AND DISCUSSION

Characteristics of the respondents

Majority of the respondents were female (Table 1). Women within the study areas proved more knowledgeable on high oil yielding shea tree ethnovarieties than their male counterparts Mawa (2016). This is an indication that women handle shea tree products on more usual occasions than their husbands who only get concerned after the women have sold the products (oil or kernels). Women were further identified as key players in the upstream level in promoting shea butter value chain during collection, post- harvest handling and marketing (USAID 2004).

Table 1: Socioeconomic status of the respondents

Category	Status of the respondents	Proportion of respondents (%)
Sex of the respondents	Male	46.6
	Female	53.4
Maximum level of education reached	Primary level	65.7
	Secondary	21.3
	None	11.2
	Tertiary/University	1.7
Main occupation	Farmer	82
	Informal employment	6.7
	Formal employment	5.6
	Business	3.4
	Studying	2.2

Level of education is an important factor in enhancing local knowledge (Fredi *et al.*, 2018). The more educated respondents gave a more consistent and reliable information regarding shea tree types in their areas. The association between level of local knowledge and level of education was not significant (0.16). This is an indication that higher level of education influences the aptitude and reasoning capacity of an individual. Local knowledge basically deals with learnt knowledge as one grows and uses shea tree products. The farmers get to discover differences in fruit shapes; taste; color and texture that equip them in developing preferences to some traits over time. This is important because any plant breeding programme should target the interest of the end users whom the community are key. The difference in local knowledge between farmers of Teso and Lango farming systems was weakly significant although the general difference among all the study areas differed significantly ($x^2 = 9.837$, df = 4, p = 0.043).

Land and shea tree ownership in Uganda

Over 50% of the respondents were above 45 years old owning 5 acres of land on average. Below 25% of the respondents were below 35 years old owing 3 acres of land. In general, the average land size owned by most of the farmers was 7 acres possessing 27 shea trees on average giving average standing density of three mature shea trees per acre (Table 2).

Table 2: Average land size and shea trees owned per respondents

		Respondents' age (years)	Size of land owned (acres)	Number of shea trees on land
Mean		46	7	27
Median		45	5	15
Std. Deviation		16	7	33
Percentiles	25	35	3	8
	50	45	5	15
	75	57	8	30

These shea trees are owned by men (65%) and family members (18%) – see figure 1 below. Single mothers headed families attached shea tree ownership to the women if the children were still young and if the land had not yet been divided among the children. Each farmer

with shea trees on his/her land had a vast knowledge on the different types of shea trees on-farm, their phenology, traits and the preferred traits that have been selected over time. The farmers with larger pieces of land had on average more diverse shea types and stems. This also widened their knowledge on shea tree typology and experiences. This kind of differed tree ownership is a factor of land-tree tenure in a specific area. Throughout African, land-tree tenure determine the right to use or harvest a given product from trees on that land although communal ownership also exist where the community members are the only ones allowed right of use. It was noted that although claims of shea tree ownership were attached to the men/husbands, women and children were the major role players in harvesting and post-harvest handling of the shea fruits and seeds for oil extraction and sale (Figure 1). The men claimed full responsibly when it came to converting the tree into charcoal for sale. They also gave their strong reason of sharing monies from the sale of the shea kernels and oil that they are the owners of the trees although they did not directly get involved in collecting and processing the saleable products (Boffa *et al.*, 1996).

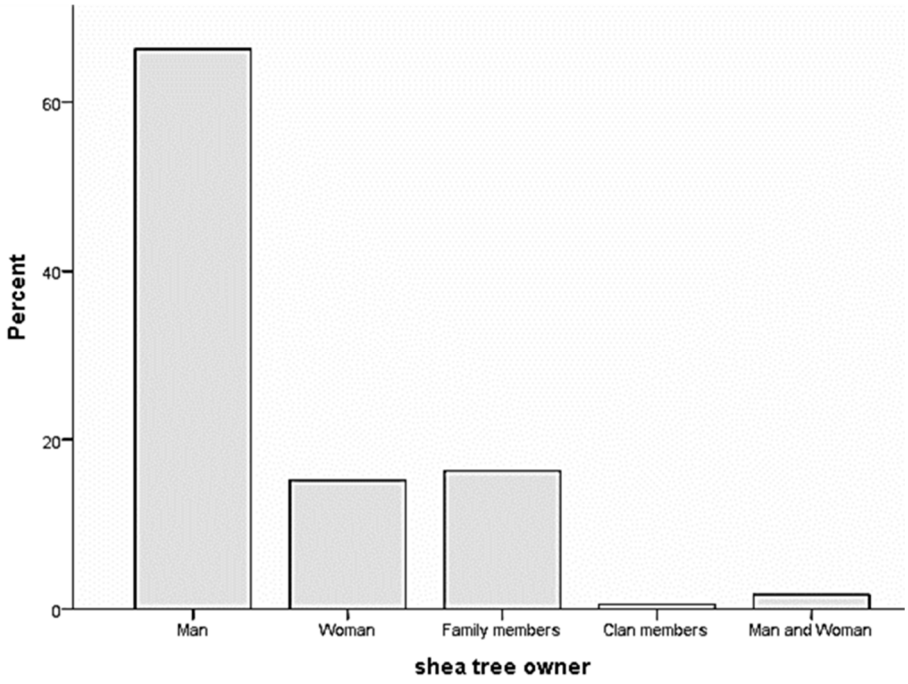

Figure 1: Shea tree ownership in Uganda

Researchers conducted in Nigeria (Jamala *et al.*, 2013), Ghana (Techno serve 2004) and Uganda (Gwali *et al.*, 2013) identified women as the major players in collection and processing of shea products. This has greatly contributed to their local knowledge on shea tree typology, products and services. Although they actively engage in the shea collection and products processing, they are majorly found at the very upstream end where labor engagement is too high and benefits are low. As a result, they end up benefiting less from the industry due to low farmers' margin arising from low bargaining power emanating from individual farmer marketing. Despite of the above, women are still empowered economically as they participate in the value chain.

Importance of shea trees and products to rural livelihood in Uganda

Shea trees offer various benefits to the communities where they grow. The fruit pulp supplements household food and nutrition as they are consumed to supplement food during

the hunger period (Jasaw *et al.*, 2015). The kernel provides fats and fatty acids (oleic, stearic, linoleic, and palmitic acids) (Gwali *et al.*, 2012). Shea trees play a major role in nutrient recycling when the leaves and fine roots decompose and a major source of oil for the local communities (Bayala *et al.*, 2006) although the leaves decompose at a low rate (Bayala *et al.*, 2005).

The communities realize the importance of shea nut tree from the fruits, oils, income, cosmetic and medicinal ointments, hair cream, soaps illuminant and water proofing materials, fuels to the various services it offers (Table 3).

Table 3: Benefits of shea trees derived at household level (n=246)

		Proportion of the respondents (%)
Benefits of shea butter tree	House hold food and nutrition security	56.2
	House hold income	29.8
	Firewood	7.9
	Cosmetic oils	3.4
	Charcoal	2.8
Shea tree products sold	Oil	56.2
	Seeds	41.6
	Fruits	1.2
	Seedlings	1.1

Most community members benefit from shea trees for food and nutritional security (56.2%). This includes fresh fruit pulp eaten to provide quick energy when the farmers are either digging or just from the gardens. The sweet pulp, full of sugars are therefore eaten while preparing the next meals. This is important in subsidizing family diet during periods of low food supply (Table 3). The tree product (kernel and oil) provide a good household income mainly for women and children who sell in the local markets. Home processed oil is mostly traded on, followed by kernels (Figure 2). The importance of shea trees to smallholder farmers' livelihoods has enhanced their local knowledge on the high oil yielding and early maturing shea trees in Uganda. This is because the farmers have co-existed with the species for the rest of their lives.

Figure 2 points out the proportions (%) of respondents why local farmers deliberately protect shea trees on their farms. It highlights three major reasons as oil production both for sale and domestic use, food and nutrition provisioning and tree intercrop under agroforestry system through farmer managed regeneration.

Most (54%) of the farmers maintain shea trees in their farms in order to process oil both for domestic use and income. Others responded that they maintain shea trees on their farmlands for food and nutrition (26%) and intercropping (2%).

Shea trees and shea products offer a wide range of products and services that improve community livelihood in the areas where they grow. Through their close interaction with the species, the communities have co-existed with the tree for decades and therefore, has become part and parcel of their livelihood. This has benefited them a lot through sale of shea products to earn household income. Products like oil, kernel and wood fuel are sold and children educated, food staffs bought for home consumption, medical services acquired and clothing purchased for the family members. The domestic oil consumption saves the family from purchasing cooking oil from the markets as such saving the money for other household uses.

On the other hand, the nutritious shea fruit pulp/fruits provide household food and nutrition security during the fruiting seasons. These trees are majorly found randomly placed within

the farmlands providing shading and protection to agricultural crops from intense sunshine and strong winds.

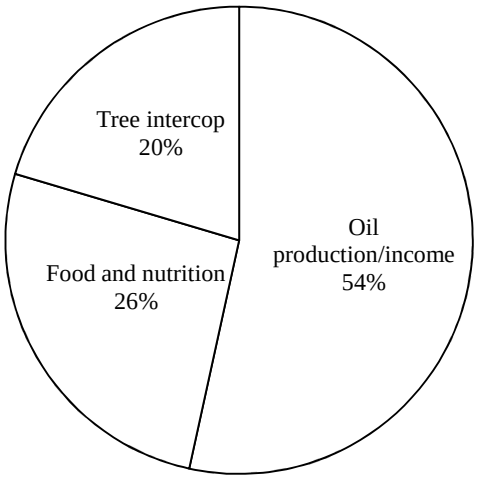

Figure 2: Reasons why local farmers deliberately protect shea trees on their farms

Distribution and state of shea trees on farm

We analyzed the status of shea trees on farm whether they are increasing or not, whether the available shea trees are selected for or not or whether they are planted or they grow for themselves and where they are located on farm. This has been summarized in table 4 below.

Table 4: Status of shea tree on farm (n=246)

Shea tree status	Response	Proportion of respondents (%)
Changes in shea tree population over the last 10 years	Increased	74
	Decreased	26
Whether shea trees regenerate on farm	Yes	77
	No	23
Whether shea tree types are selected for protection on land	Yes	65
	No	35
Where shea trees are located on farm	Scattered	67
	Boundary	30
	Plantation	3

Majority of farmers noted increased tree population on farm (Table 4). This could have been due to the number of local efforts to protect the species where the cultural institutions, local government authorities and a number of NGOs have spearheaded formulation of by-laws banning cutting and burning charcoal from the tree. Such by-laws are also supported by the fact that there is also growing demand for shea tree products where the farmers can easily sell, such as oil and kernel to local markets and retailer buyers from local centers. Deliberate maintenance of shea trees on farm is a form of agroforestry system curried out by retaining economically viable trees on farmland which remarkably increase profit per unit area of rural farmers' land. This practice is termed as Farmer Managed Natural Regeneration (FMNR). The maintained tree species greatly supports and maintains livelihood of the rural people by

playing significant role in diversifying food security and household income (Jamala *et al.*, 2013). Although shea trees are such important to household livelihood, there is no deliberate effort to plant on-farm by the farmers who only maintain natural regeneration (Table 4). However, a number of farmers make efforts to select preferred shea tree traits for protection on farm. These traits are dependent on the phenotypic characteristics guided by their growth forms (Dianda *et al.*, 2008) but not based on the ethnovariety selection given the fact that differentiation of the types is based on fruit type but not tree characteristics. Even if this would be possible, it becomes very difficult for farmers to differentiate between the ethnovarieties when the trees are still young. Most of these trees are found scattered on the farmland (67%) given the sporadic distribution and farmer random selection methods (Gwali *et al.*, 2011).

Farmers' shea trait preference

Farmers ranked five top preferred shea tree ethnovarieties in their areas based on the level of oil production and farmer preferences across the study areas. Four ethinovarieties were majorly selected due to their traits preferred by the community (figure 3). Two traits (High oil content and tasty/sweet pulps) were most preferred by the farmers across the study areas. According to the different communities, judgement on those enthinovarieties that exhibited the shea tree preferred traits were selected per district as presented in figure 3 below.

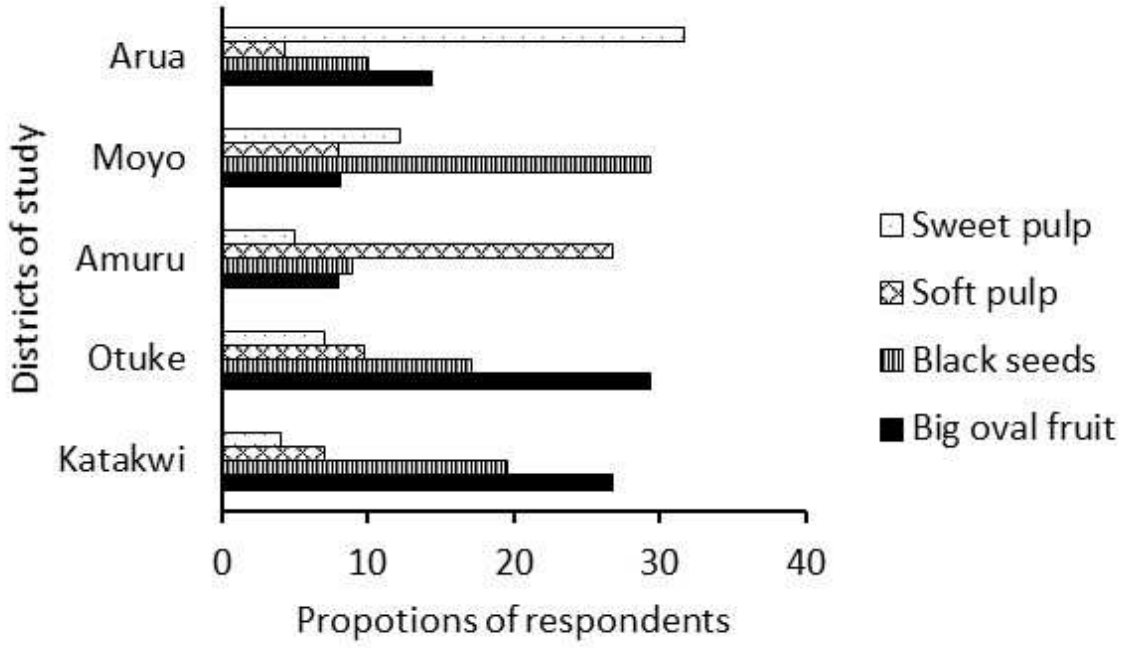

Figure 3: Farmers' choice of the different shea tree ethnovarieties with high oil production

Farmers' local knowledge in high oil yielding shea tree ethnovarieties differed among the communities of the different locations. Although the difference was realized, it was clear that farmers mix shea nuts from the different ethnovarieties while collecting the fruits from the farms. Farmers therefore have limited knowledge on the real shea tree ethnovarieties which contribute more oil to the oil pool when compared to the rest. This is one area recommended for further research. Farmers have it that black seeded ethnovariety is with higher oil content than other types although the variety was only given highest preference in Moya district

(30%) followed by Katakwi and Otuke districts (19% and 15% respectively). Although Gwali *et al.*, (2013) also reported so, this research found a divergence of this notion. The respondents from Teso, Lango and Acholi farming systems based their local knowledge on the size of shea tree fruits/seeds while West Nile respondents had a congruence of local knowledge. The general ranking of all the ethnovarieties in Uganda revealed that farmers' local knowledge in grading shea tree ethnovariety with highest oil yield consider big seeded shea tree types (figure 4).

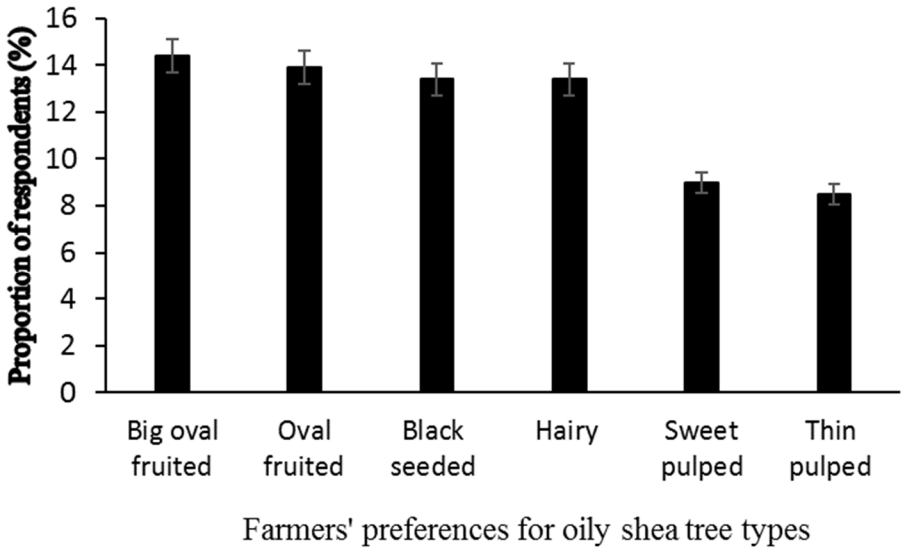

Figure 4: Generalized local knowledge on the highest oil yielding shea tree ethnovarieties in Uganda

Farmers' local knowledge on shea trees with high oil yield was based on the morphological characteristics of the fruits majorly due to size of individual fruits/seeds. The farmers believed that bigger kernels produce more oil than the small kernels. Rarely can this assumption be true as the seed mass-volume ratio cannot be the cutting line to this fact. Although Okullo *et al.*, 2010 reports on the physico-chemical characteristics of shea butter oil in Uganda with oil content ranging from 41-54%, this only points at the variability of oil productivity between the shea tree growing areas as a whole. There is therefore need for further research on the various ethnovarieties to identify the contribution owing to shea oil productivity from individual ethnovarieties. This will clearly address the gap on which ethnovariety produces more oil, such trait could be used to breed for high oil yield in Uganda. Other studies on the components of shea oil (Boadu *et al.*, 2017; Honfo *et al.*, 2014; Israel,2014 and Zaidul *et al.*, 2014) only reported the elements of fatty acids contained in the shea oil and did not also point out which shea tree ethnovariety contributes much of the important components. The respondents were further subjected to a question to identify the preference between high oil yield and sweet/tasty shea pulp. This was to assess farmers' choice of the two traits which has been key in improving household livelihood. Most of the respondents indicated preference to tasty pulp and high oil yield as a linked trait (98.2%) of whom 67.4% preferred shea trees with only high oil yield and the rest prefer tasty pulp (figure 5)

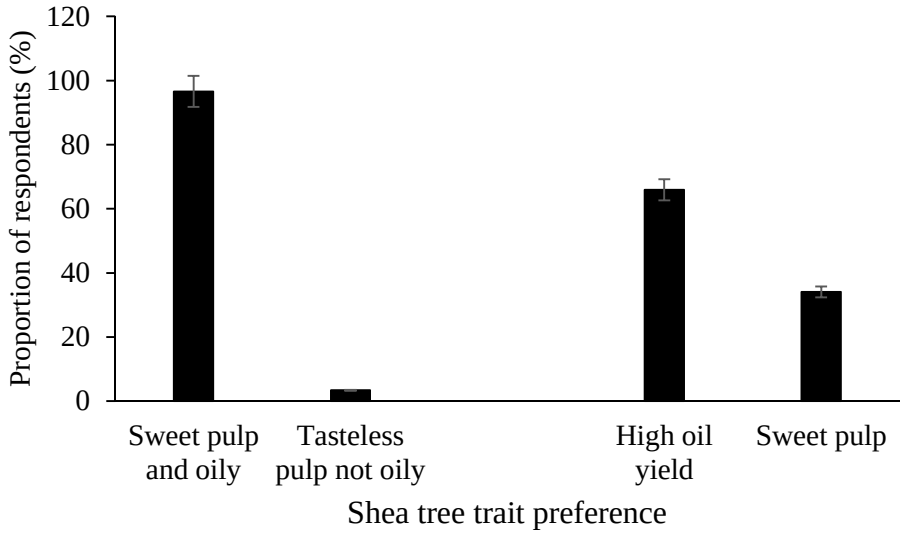

Figure 5: Farmers' indication of preference to shea tree traits (high oil yield and sweet pulp)

The most beneficial product from shea tree is oil although the tasty pulp is also eaten to subsidize household diet (Table 3). Generation of shea tree variety with high oil yield will positively contribute to community livelihood as the quantity of oil produced per given kernel will be high improving household income. Oil production in West Africa yields between 30-40% of Shea butter from raw nuts using mechanized method (Addaquay 2004), although local production method can yield as low as 25% using traditional and semi-mechanized systems (Jamala *et al.*, 2013).

CONCLUSION

This study has revealed the differences in local knowledge and preferences for shea ethnovarieties among the communities in Uganda. Whereas it was believed that bigger fruit/seed sizes and block seeds produce more oil, this may not be so. This calls for further research to determine the quantity and qualities of oil produced by the different ethnovarieties. It will be appreciated that local knowledge is useful in determining baseline information required to start shea tree breeding programme. This is important in the fact that breeding is done to meet the needs and aspirations of the end users whom the communities are. On the other hand, other none preferred shea tree types also require protection given the fact that human preferences change over time and therefore, those none preferred ethnovarieties may find preference in the future.

RECOMMENDATIONS

Further research to identify the shea tree ethnovariety with the highest oil quality and quantity to back the local knowledge results give in this research.

Any future shea tree breeding programme should target the preferred traits (High oil yield and sweet taste). This can aim at increasing the size of fruits and taste which will be in line with the local knowledge that bigger and black seeds produce more oil.

DISCLOSURE STATEMENT

The authors would like to state that there is no any potential conflict of interest in this paper or out of research carried out to generate information in this paper.

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